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Methodologies for energy performance assessment based on location data

Proceedings of the workshop
Ispra, 12-14 September 2016

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Abstract

This expert workshop is one of a series covering the following topics: energy, buildings, location, assessment methods and data in relation to European Directives on Energy Efficiency (EED), Energy Performance of Buildings (EPBD), INSPIRE, establishing an Infrastructure for Spatial Information in Europe and the Covenant of Mayors (CoM) initiative.

These workshops are jointly organised by the EC DG JRC project on Energy and Location and the European Union Location Framework (EULF) action of the EC ISA Programme (Interoperability Solutions for Public Administration)[1]. So far the JRC team has produced a feasibility study[2] and started a dedicated pilot project on location data for buildings related energy efficiency policies[3].

The first event organised was the workshop on "Spatial data for modelling building stock energy needs" held at JRC in Ispra 23-25 November 2015[4].

The aim of this second workshop was to discuss different approaches and methodologies to assess energy efficiency measures as well as energy usage and monitoring of energy flows at building, urban and regional level, representing an opportunity to share information, integrate stakeholders' views and set the ground for mutual collaboration.

Eleven invited leading organisations and EU projects were invited to take part in this workshop sending experts to present their projects and discuss how to assess synergies and how to arrive to a coherent approach for assessment of energy use in the built environment. Another twelve people from JRC, experts on energy efficiency, energy performance, geospatial data modelling and processing participated to the workshop.

From the discussions, it has emerged that a holistic approach would give more evidence of the needs for measures to reduce energy consumption. This is a bit in contrast to what the EU policy requests by the present energy related Directives. More and more it becomes evident that the target should be reducing emissions and not necessarily reducing energy consumption. Integration of energy technologies are playing an important role at a higher level than the building only (i.e. at the EPBD–level). The energy market (gas and electricity) is able to provide an enormous buffer in storing energy virtually and the buildings itself should be much better balanced in energy terms to the thermal needs, e.g. heating and cooling. At the same time the energy network requires buildings for balancing.

INSPIRE could be very relevant for energy assessment in the built environment and for this reason the Energy Pilot initiated under the "Energy and Location" and "European Union Location Framework" projects will be continued over the next years. Main objectives of the pilot project will be to continue to work on Use Cases already outlined, to be further elaborated based on the information gathered at the workshop. The JRC will seek to develop partnerships to implement the defined use cases with the selected partners.

[1] http://ec.europa.eu/isa/actions/02-interoperability-architecture/2-13action_en.htm
[2] http://publications.jrc.ec.europa.eu/repository/handle/JRC96946
[3] http://e3p-beta.jrc.nl/articles/pilot-project-energy-and-location
[4] http://e3p-beta.jrc.nl/articles/follow-workshop

1 Introduction

This expert workshop is one of a series covering the following topics: energy, buildings, location, assessment methods and data in relation to European Directives on Energy Efficiency (EED), Energy Performance of Buildings (EPBD), INSPIRE, establishing an Infrastructure for Spatial Information in Europe and the Covenant of Mayors (CoM) initiative.

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The first event organised was the workshop on "Spatial data for modelling building stock energy needs" held at JRC in Ispra 23-25 November 2015[8].

The aim of this second workshop was to discuss different approaches and methodologies to assess energy efficiency measures as well as energy usage and monitoring of energy flows at building, urban and regional level, representing an opportunity to share information, integrate stakeholders' views and set the ground for mutual collaboration.

JRC identified three different approaches for the assessment of the energy performance of buildings based on measured data, on calculation methodologies and on a holistic approach. All three approaches have in common the use of geolocation data for a better quality of input data and for the scaling up of energy needs of buildings, districts, urban areas and countries; see figure 1. This information is important for making decision on refurbishment, investing in renovation and managing the energy flows. The methodologies allow assessing the impact of energy efficiency measures implemented in the framework of energy efficiency policies and initiatives, such as the Energy Performance of Buildings Directive (at building level), the Covenant of Mayors initiative (at urban level) and the national energy efficiency action plans presented by Member States in the framework of the Energy Efficiency Directive. Scalability is an important aspect and a proper implementation of the INSPIRE Directive for a harmonized approach to geolocation data in Europe will facilitate the handling of data from diverse resources. In general the methods are based on available data and required output. Quality and uncertainty on data is an important issue in particular when dealing with big data.

Energy in built environment needs the facilitation offered by INSPIRE harmonisation of data, whereas at the same time INSPIRE would see its potential realised in a big and important theme such as energy in the built environment. After all it is one of the major pillars of EU policy to bring down GHG emissions and energy consumption. Note that in Europe up to 40% of final energy is consumed in the residential and tertiary building sector and has an important potential for energy reduction and for reducing GHG emissions.

The advantages of implementation of INSPIRE should be more highlighted, e.g. scalability (from building to Member State level), creation of real time services (utilities, energy markets and end-users) and the handling of big data for decision-maker (static mapping of buildings).

Eleven leading organisations and EU projects were invited to take part in this workshop sending experts to present their projects and discuss how to assess synergies and how to arrive to a coherent approach for assessment of energy use in the built environment. Another twelve people from JRC, experts on energy efficiency, energy performance, geospatial data modelling and processing participated to the workshop.

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[7] http://e3p-beta.jrc.nl/articles/pilot-project-energy-and-location
[8] http://e3p-beta.jrc.nl/articles/follow-workshop

A summary of the presentations held in all the workshop sessions is reported at the end of this report, whilst the integral version of the scientific papers submitted by the invited experts to the workshop organizers, and from which they extracted their presentations given during the workshop are provided at the following link:

http://kcee-dev.jrc.nl/events/methodologies-energy-performance-assessment-based-location-data

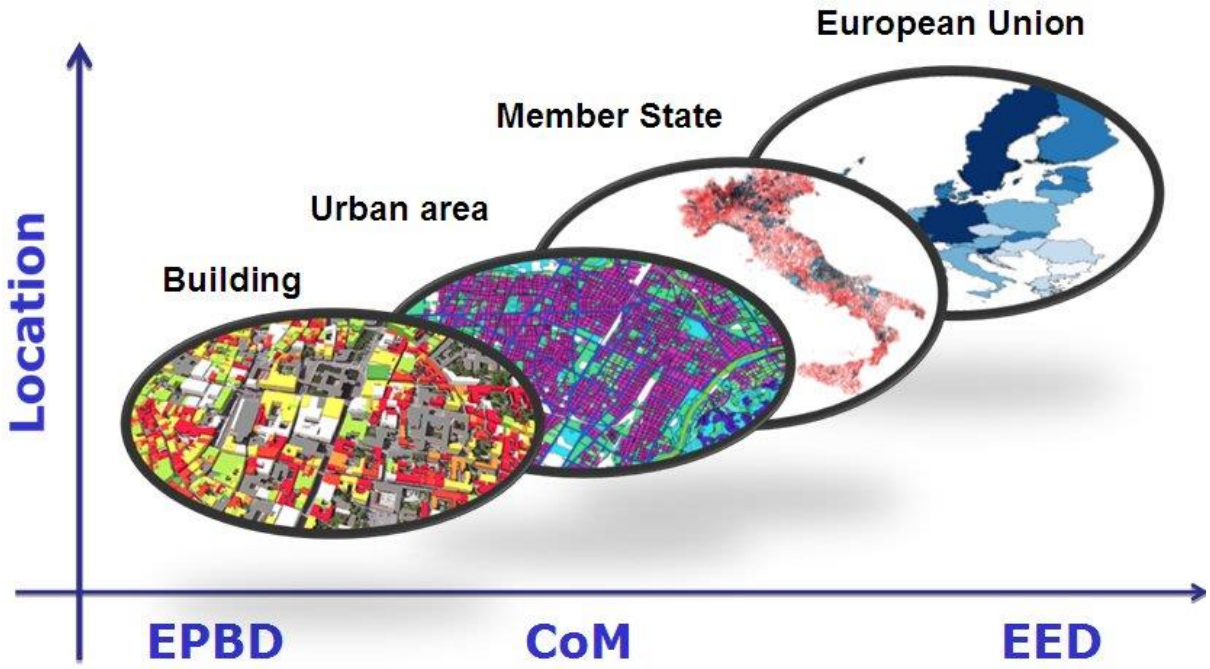

Figure 1. Scaling and the relation between EU Directives and location

2 The JRC Energy Pilot

The EULF Energy Pilot is one of the three pilots (the other two dealing with Transport and Marine sectors, respectively) to test the concept of the EULF. It started in the last quarter of 2015, based on the outcomes of a feasibility study which are documented in the "Location data for energy efficiency policies" JRC Technical Report[9]. The feasibility study, concluded in 2015, aimed to verify the potential for an effective application of spatial data to support the monitoring requirements of the different EU energy efficiency policies and initiatives, which include data from different sources and at different scales (building, district and national).

It confirmed an approach to support the data monitoring requirements of the Energy Performance and Buildings Directive (EPBD), the Energy Efficiency Directive (EED) and the Covenant of Mayors (CoM) initiative, based on the re-use of INSPIRE (2007/2/EC) components. The study made an initial analysis of the data flows relevant to EPBD, EED and CoM, identified relevant INSPIRE data themes, and carried out an initial mapping exercise. Because of the variations in available data and the need to link data at different administrative levels, there is a need to properly combine data of different nature (e.g. calculated vs. measured, static vs. dynamic). As these policies are linked to energy savings actions, validation and interaction with building owners and industry is important in the overall methodology.

A pilot project is now underway with an initial kick-off workshop held in Ispra from 24-26 November 2015. The second workshop took place in Ispra from 12-14 September 2016, and is the subject of this report. The pilot will involve a series of cities and regions to demonstrate how an integrated data approach can be established for planning, implementation, monitoring and reporting for the multiple policies and initiatives, considering energy performance of buildings, energy consumption of buildings and energy production at a local level.

This will be done through:

- adoption of common structured data models (extending some INSPIRE core data models)
- use of common data access mechanisms (INSPIRE Network Services)
- re-use of (parts of) datasets for different planning, implementation, monitoring and reporting purposes
- data access agreements to use the relevant data development and application of relevant methodologies and models to fill data gaps use of both centralised and distributed ICT infrastructures which make accessible the data needed to fulfil planning, implementation, monitoring and reporting requirements

The pilot will be implemented and tested through a series of use cases, involving different stakeholders (public authorities at local and regional level), businesses working in the energy sector and citizens (building owners):

- Use Case 1 – INSPIRE Harmonization of existing Energy Performance Certificate datasets and creation of a web application for accessing them.
- Use Case 2 – Benchmark of different Energy Performance Labelling of buildings.
- Use Case 3 – Assessing the Energy Performance of buildings with dynamic measured data.
- Use Case 4 – Supporting Energy Efficiency driven renovation planning of the building stock at local level.
- Use Case 5 – Supporting integrated energy planning and monitoring at urban/local level (SEAP BEI/MEI).

[9] http://publications.jrc.ec.europa.eu/repository/handle/JRC96946

- Use Case 6 – Supporting the design and implementation of a regional energy strategy.

In terms of pilot timeline, Use Case 1 is already running, the detailed definition of the Use Cases 2, 3 and 4 are about to be finalized; new use cases can be identified.

3 Invited experts to the workshop

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Hans Bloem
Isabella Maschio
Albana Kona
Jean-Francois Dallemand
Silvia Rivas
Chiara Lodi

C3 - Energy Security, Distribution & Markets – Head of Unit: **Marcelo MASERA**
Gianluca Fulli
Giuseppe Prettico

4 Summary of the presentations

4.1 Setting the context

The workshop was opened with a presentation by **Maria Teresa BORZACCHIELLO** on the underlying context. The INSPIRE Directive sets the principles for sharing harmonised spatial data for environmental policies in Europe, but is relevant also in other non–environmental domains. On the other side, the EC Better Regulation initiative provides for better design and evaluation of EU policies and laws. The energy sector presents challenges for both aspects of data sharing (including location-based information) across Europe and Better Regulation, in particular regarding the better monitoring of the Energy Performance of Buildings Directive (EPBD), the Energy Efficiency Directive (EED), and the Covenant of Mayors initiative. On this basis, the Joint Research Centre (JRC) has started a dedicated "Energy and Location" pilot project in November 2015, on the opportunities of the use of location information to support the European energy efficiency policy lifecycle.

The second introductory presentation, by **Giacomo MARTIRANO**, focused on the scope of the workshop: an overview of the methodologies for the energy assessment of buildings and cities that are based on location data. Giacomo made a summary of the previous work (JRC reports and first workshop) and illustrated the Use Cases that, once their definition will be finalized, will be developed by the JRC as part of the Energy & Location pilot project, in the framework of ELISE action of ISA^2 and of JRC institutional activities. The titles of the Use Cases are reported below:

Use Case 1 - INSPIRE harmonisation of existing energy performance certificate (EPC) datasets and creation of a web application for accessing them

Use Case 2 - Benchmark of different Energy Performance Labelling of buildings

Use Case 3 - Assessing the Energy Performance of buildings with dynamic measured data

Use Case 4 - Supporting Energy Efficiency driven renovation planning of the building stock at local level

Use Case 5 –Supporting integrated energy planning and monitoring at urban/local level (SEAP BEI/MEI)

Use Case 6 – Supporting the design and implementation of a regional energy strategy

As first reactions to the use cases described: some discussions are foreseen on the different definitions of buildings, building units and on the attribution of EPCs (to building unit and to building). A second comment was to focus on reducing the emission footprint and not only the energy footprint of buildings (in order to avoid risk of displacing and increasing emissions). It was also recommended to pay due attention to the validation of the output, where a specific procedure is needed (e.g. use case 1).

A brief presentation, made by **Isabella MASCHIO**, followed to inform the participants that the JRC is developing the European Energy Efficiency Platform (E3P) as an open and collaborative platform and that a working group "Energy and Location" has been created where experts can keep in contact and collaborate.

Hans BLOEM then gave a deeper introduction to the energy efficiency, energy performance of buildings and energy in cities contexts in Europe. He also gave an overview of the possible approaches to assess the energy performance of buildings that can be: measured, calculated or holistic, with different steps depending on the data used. Hans highlighted also the role that INSPIRE can play in ensuring a better quality of the input data.

At the end of the introduction, Hans explained that the expected outcomes of the workshop include mapping the participating experts' approaches with the methodological

approaches outlined in his proposed classification. These would be then associated with use cases, and scales of application (at building, district, city, region, national level).

4.2 Presentations by invited experts

Vittorio VERDA presented the DIMMER project for energy efficiency and economic evaluation, based on the Energy Efficiency Engine, a thermo-fluid dynamic model that minimises the sum of the users' thermal request, in a multi energy networks approach, applied to the cities of Turin and Manchester. This is a semi-empirical method to simulate energy consumption in buildings.

The aim of the model is to perform heat peak shaving and shifting from electricity to heat. The objective is to define a strategy based on modelled results confronted with measured buildings data, iterative model. The model is not yet implemented at full network level. The first results obtained show a total heat demand reduced by 1%, and a good shifting.

Questions were made on:

- building data availability: an online platform has been set up to collect data
- price of energy considered: the model considers a day-night tariff (as it is common in Italy). It was commented that in DK it is different, the heat prices changes with the market price and users should get the message.
- use of Heating Degree Days (HDD): it would better be replaced by a heating index, considering solar gain, different comfort levels. Note that HDD are mostly linked to annual assessment of building heating energy needs and not necessarily to other conditions.

Piergiorgio CIPRIANO presented various projects where location data play a role in the energy assessment of buildings and/or cities:

- CityGML ADE is working on the definition of standards for interoperability of models at urban level. It is an open data model for 2D as well as 3D urban data.
- Geosmartcity.eu project: investigated the harmonisation of data and metadata from the semantic point of view, as well as from their publication (through web-services) point of view, in relation to a "green energy" scenario. Data model extensions of INSPIRE schemas for Buildings have been also presented.
- SUNSHINE project: the project produced the energy map of Ferrara (40 000 building data), with a specific methodology for energy performance calculation, based on the TABULA approach, in conjunction with energy consumption measured data.
- ACCENT project: developed tools to support urban energy planning for buildings, providing maps and data. Pilot cities are Paris, Valencia, Reggio Emilia and Ferrara.
- CitiEnGov is an Interreg project developing tools for integrated territorial planning to enhance the use of renewable energy sources and improve energy performance of buildings.

Common points and main obstacles of the presented projects are heterogeneity of source data and issues about data availability, accessibility, and level of details, licenses and semantics. All can vary from country to country (but also from city to city). Data from energy performance certificates, or energy consumption data can be easily geocoded (Point of Delivery (billing unique identifier) > address > building) but often aggregation and anonymisation of data is required. CityGML Energy ADE and INSPIRE are two target data schemas that are useful to integrate heterogeneous energy-related geodata. Existing web-services or platforms already implemented need to be interoperable and well-known geo-ICT standards (e.g. OGC OWS) can help.

A list of open questions was shared (refer to the presentation) in particular on data, datasets, data access, tools, standards, projects, buildings and cities.

Volker COORS gave a presentation on the Stuttgart 3D city model, based on SIMSTADT urban simulation tool and 3D visualisation. The team is collaborating with the Energy ADE group for CityGML.

Many proposals were shared:

- To develop a **EU scale platform for urban energy simulation**, using a common urban information model, with a methodology based on SIMSTADT, providing a 3D building database for EU. In order to elaborate also energy performance of buildings, LoD1 (simple 3D model of building with footprint and height) which is already available is sufficient; LoD2 (includes roof shape) is not freely available, but it would improve the results, now 80% of coverage is achieved. With LoD3, also façade details would be available. Next step could be to develop a 3D model at LoD1 for NL (data will be available from TU Delft). Then following (Iterative steps) development should be: heating demand simulation (Ludwigsburg), add another EU city (Vienna), guidelines and interface for other cities to use the platform and upload data, scale up to national level (e.g. NL)
- **Simulation as a Service for citizens** (City of Essen): thermal imagery, crowd sourced data collection on renovation (benefits for the users to support their engagement)
- **Sensor Observation Service**: integrate measured data in simulation (e.g. declared building volume is often different from measured volume by 20%). Management of data (large datasets) can be: centralised at EU level (!) or distributed but accessible (national platforms and interoperable interfaces).

The two main challenges identified are:

- data availability: LoD1, year of construction, building usage, would be a good starting point; renovation information would improve the model
- data privacy and conditions for data use (e.g. census data)

Some references were mentioned:

- "State-of-the-art of 3D national mapping in 2016", presented at the International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLI-B4, 2016 , XXIII ISPRS Congress, 12–19 July 2016, Prague, Czech Republic
- Google Earth Engine as a global platform for Earth science data & analysis

Martinus VRANKEN presented the Dutch system of national key registers, which are (partially) interoperable and (partially) accessible. The 8 presented linked registers (address-building-ownership) allowed to develop an approach for the energy labelling of buildings that is based on a provisional energy label (estimated through the national key registers, energy systems are not included) and a final energy label (which is obligatory for transactions; here energy systems are included). The ambition is to provide a full open access to geo information in NL. The lowest level of definition is the self-contained unit (approx. equivalent to "building unit").

A provisional energy label is based on year of construction and dwelling type (detached, residential…) and GIS analysis. The model is corrected for statistical "building renovation trend" (ref to publication by RVO on building renovation trends in NL). Based on measured data, a trend in energy label/year of construction can be identified (with a sensible change in 1975). A reference table is produced for provisional labelling based on dwelling type/year of construction.

It was highlighted that that not many municipal buildings have an energy label yet. An issue is with cadastre information is that some data are free but some other data must be bought unless they are aggregated. For privacy issues, Statistics Netherlands (CBS)

groups the energy consumption data of buildings by five at least with the same post code. It was also noted that the energy performance of buildings is improving but consumption is slowly increasing (rebound effect?).

There is a plan to develop a National Energy Atlas to support the energy transition in The Netherlands, including the improvement of the energy performance of buildings. It is based on year of construction and dwelling type (detached, residential…) and GIS analysis. The model is corrected for statistical "building renovation trend" (ref to publication by RVO on building renovation trends in NL). Based on measured data, a trend in energy label/year of construction can be identified (with a sensible change in 1975). A reference table is produced for provisional labelling based on dwelling type/year of construction. This atlas would also allow identifying nearly-Zero EnergyBill buildings that would be the ones to be refurbished first.

A useful layer for this atlas would be the subsurface database (it is a geological information database of interest for heat pumps, e.g.), but subsurface networks are not represented yet.

Concerning the energy performance of office buildings, the same approach has been adopted: cross-relating key registers, provisional labels are estimated by year of construction (through a reference table: average energy indexes (?)/year of construction (table ECN)).
A (grand) open question was posed by Martinus: which information on energy performance of buildings (and at what level of detail) is needed by the EU to reach the goals of the Paris Agreement of December 2015?

Paul RUYSSEVELT's presentation was divided in 2 parts:

Part 1. **The IEA EBC Annex 70 on Building Energy Epidemiology:** it would be interesting for the informal network on energy and location to collaborate with this IEA annex 70. The subtasks are:

- A: stakeholders
- B: data and methodologies
- C: building stock modelling and analysis

Bottom up models are based on archetype/iconic buildings; probabilistic models are based on samples of buildings. Both are considered in Annex 70). Holistic approaches are too complex.

Part 2. **The UK building stock model**

The 3D UK stock model of buildings is based on 15 house types for the residential sector, it has been used for many years for building related policies. For non-domestic buildings it is more complex and heterogeneous, work is ongoing.

For the residential sector, the UK building stock is based on hereditaments (see Steve Evans, 1st Energy and Location workshop). Access to energy data is more difficult since after liberalisation more actors are present in the market and now data belong to private/commercial companies (retailers), only individual access is possible (not bulk).

For non-domestic activity, a combination of information is needed from: hereditaments (taxes) identifying self-contained units (The definition is different from other countries), use of buildings (multiple activities are possible). LiDAR data with 1 m2 resolution (give information on roof structure) are also considered. Additional models' outputs are considered such as: SimStock (3D stock data that requires additional data to provide the built stock energy model), Tall Buildings, GEAMA (geometry, energy, activity, materials and ages).

Possible applications are to estimate the importance of heat in the non-domestic buildings (NDB), the efficacy of retrofit measures, identify the quick wins, urban

planning. Note that for the NDBs, the last renovation date is more relevant than the date of construction.

The model has been applied to Camden high street.

Comments and discussion: The occupancy is taken into account as schedules, it can be improved later. Google Streetview could be used to improve the energy information for the built stock. The stock model was more used for building use than energy performance, therefore energy information is lacking. The BEES building energy survey collected information from 10k properties by phone and it was used for urban planning application. Some walk-by surveys were also performed, using inference tools (presence of air conditioning based on presence of other elements).

Jordi CARBONELL presented the following four projects that CIMNE is involved in:

IEE-EMPOWERING: aims at providing feedback to the users in order to induce energy savings. The project collected 2 years of consumption data (hourly) in different EU countries, analysed anonymised data (grouped by postal code). Communications to end-users were provided through the utilities.

SEMANCO –the project aimed at improving urban planning and energy management using existing data for the building stock and the semantic meta-integration of multiple databases. The simulation of the energy consumption in buildings is based on a statistical model (data were not made available by municipalities).

The Catalan strategy for rehabilitation, is ongoing. The lines of action are: information system, involvement and training, innovation products and services, organization model, investment and financial actions.

The EDI-net project is an energy data innovation network, only on public buildings, it relies on smart meter data (energy and water), cadastral data, meteorological data (hourly), and renovation measures. The target group is the group of building managers. It aims at modelling the consumption of the public buildings, identifying weekly consumption patterns and allowing for comparisons: historical with same building, with similar buildings, with energy efficiency measures. Emphasis is given to the visualisation of the results. Among the conclusions: the use of open source software facilitates the massive exploitation of the results.

For the model, improvements can be foreseen by considering more patterns. Additional improvements are expected in the evaluation of energy efficiency measures and action plans.

Open questions and issues: A typical problem has been linking cadastral reference with single buildings (there is typically one cadastral reference for more than one building) and linking energy consumption with single buildings (there can be one energy meter for more than one building). There is a need to define a standard way to register the occupancy of buildings (consider holidays, tourists). How to collect "information consumption" for the residential and private sector? Once more the issue of data protection vs data accessibility was highlighted.

Discussions: Could a Green Button tool be interesting to communicate results to the users? The Green Button (US) allows having access to consumption data even if the provider is changed.

Guglielmina MUTANI presented an energy consumption model at urban scale that includes the impact of the urban context on buildings' energy consumption. The model is combining a top-down approach (statistical model at municipality scale) and a bottom-up approach (simplified energy-use model for space heating, hot water production and electrical use). It is based on previous research results on mapping energy consumption and renewables sources and uses the CitySim simulation tool for the description of the buildings (and of their energy needs). The urban context is modelled through an urban context factor. The tool has been applied to the city of Turin.

Bruno PEUPORTIER presented a bottom-up methodology based on 3D model of one or more buildings (Alcyone, includes energy performance level and technologies, use scenario by zone), with the energy simulation model COMFIE (including multi-zone, heat transfer, air flows, lighting, HVAC, renewables). Users' behaviour is modelled through a stochastic model (occupants, appliances). Uncertainty propagation is considered. The validation of the software is made by using the Bestest procedure (IEA) and an experimental validation (IEA task 34) with good results: less than 1% discrepancy. PLEIADE users' interface has been developed to communicate energy consumption and GHG emissions levels before and after renovation. A LCA is being integrated (novaEquer) in the model. The modelling has been applied to renovation of social housing block near Paris and re-building of an urban district in Lyon, with definition of a methodology for renovation.

Future developments: use data from the France national geographic institute (ground area and height of building); consider the use of buildings, construction date and renovation (from tax administration) to elaborate house typology and simulation and estimate the potential energy savings.

Issues and needs: Energy certificates are based on theoretical performances; input data are not always precise. A common format is needed for spatial data adapted to energy performance evaluation.

The Heat Roadmap Europe was presented by **Urban PERSSON**: mapping local conditions combined with energy system modelling to identify opportunities for district heating. Considering heat demand (Solar heating, District heating), heat resources (excess heat from industry, waste to energy facilities), district heating and cooling systems and regional heat balances to produce a demand and resource mapping. The Heat Road Map allowed studying strategic heat synergies in (adjacent) regions. The outputs of the modelling: end-use building heat demand in 2050, calculation of avoided costs.

Comments and suggestions: INSPIRE could better cover the data models related to thermal networks (production facilities, pipelines) and to buildings (with connection to networks).

Nina DETLEFSEN, represented the district heating association. They have access to large amounts of data publicly available (FIE: Energy database; BBR: building database), a Data Hub is available including electricity use, building and housing. There is an interest from the utilities point of view to understand how to lower the network temperature (to reduce losses and integrate renewable sources).

Challenges: balance between open data and data privacy, aggregated data and detailed data (that come with a cost).

The main question is how to create value out of district heat data (yearly consumption at building level). From a utility point of view, to optimise the use of the network, to provide extra services, to better plan network development.

Henrik MADSEN's presentation illustrated different types of energy analysis using location and meteorological data, and based only on smart meters' data:

- In Sonderborg (DK), it allowed identifying out of the overall heat consumption, the share of space heating and domestic hot water use; and from the space heating share, the house characteristic and occupants behaviours;
- In new built UK dwellings, the analysis allowed extracting the energy characterisation of the building (energy labelling, UA and gA values estimation, energy signature, dynamic characteristics, time constants); it could also lead to proposals for energy savings, for integration of solar or wind energy, or for the integration of demand side management (DSM)

- Modelling thermal characteristic of a small office building (validation through smart meter reading?)
- Simplified district heat networks models, and dynamic analysis of supply temperature with/without predictive control
- Models of occupants' behaviour in office building (with CIMNE)
- Control of Power Consumption (for DSM) using the Thermal Mass of Buildings in DK: wind power and demand. Data from BPA (US) price responsivity analysed.
- Modelling of energy systems integration in smart cities, across building, cities, regions, and energy carriers (electricity, thermal energy, fuel) and data. Model of smart energy operating systems, including energy market, virtual storage solutions, forecasting energy generation, loads and prices.
- Can also be applied to heat pumps control based on varying prices.

Discussion: modelling tools can help integrating IT in energy systems for virtual storage solutions e.g., flexibility with district heating systems, gas systems as seasonal virtual storage, smart cities as element of smart society (with large potential for demand response). See the national Danish project CITIES that deals with integrating energy systems to achieve a carbon-free society.

Open questions: problem with tax and tariff structures, market and pricing principles to be reconsidered (better to link them to a physical entity (nodal price, capacity market).

5 Conclusions

All presentations by the invited experts have been very informative. The presented projects (mostly EU-level) complemented much the JRC presented approach on the use of specific methodologies for dedicated aims. It is at the same time clear that available data and information, require specific methods for producing, assessing and presenting the required output.

All participants are interested in collaborating and creating a network of experts on the subject through the JRC European Energy Efficiency Platform (E3P[10]), where a group on energy and location is already present.

All participants were aware of the EED and EPBD and most of them about the CoM. Only a few are addressing the implementation of INSPIRE, and the workshop contributed to raise awareness on this initiative of the Commission. The methodologies presented have all a different character and are project-specific. The classification as proposed by the JRC is an opportunity to streamline much better the requirements for input data as well as the quality of the data. It turned out that most have a holistic approach, sometimes combined with measured data and in a few cases with calculation methods. It was noted also that no project referred to the calculation method according to CEN energy standards (related to the EPBD).

From the discussions, it has emerged that a holistic approach would give more evidence of the needs for measures to reduce energy consumption. This is a bit in contrast to what the EU policy requests by the present energy related Directives. It has been discussed with emotion that energy is not always the leading target but other aspects play an important role too, such as GHG emissions and the economic impact. More and more it becomes evident that the target should be reducing emissions and not necessarily reducing energy consumption. Integration of energy technologies are playing an important role at a higher level than the building only (read EPBD–level). The energy market (gas and electricity) is able to provide an enormous buffer in storing energy virtually and the buildings itself should be much better balanced in energy terms to the thermal needs, e.g. heating and cooling. At the same time the energy network requires buildings for balancing. The challenge lays exactly there where both phenomena requires energy to balance it at a yearly level. The more a building is thermally insulated the more it will rely on management of the energy flows in the building, including user behaviour and the presence of appliances (note that the EPBD is not considering the energy use of appliances).

Intelligent (or smart-) metering may offer a proper assessment of energy performance of a building and the energy consumption by the user of the building. A simple assessment shows that an EP-class B building (or –unit) depends for about 1/3 on energy for refreshment of air. The latter demonstrates the difficulty of the present EPB Directive that requires the development of nearly-Zero Energy Buildings (nZEB) but takes into account solely the defined characteristic energy consumption for heating, cooling, ventilation, domestic hot water and lighting.

A pragmatic approach is leading to a more general adapted approach to assess energy performance of buildings than the ones suggested by standardisation bodies. Such approach could be also more understandable by policy makers and the general public affected by energy efficiency policies. Indeed, different groups need different kind of information; policy and decision makers, utilities and end-users should be addressed in different ways. The JRC team will take account of the discussions held during the workshop to consolidate the description and analysis of the different approaches to assess energy efficiency of buildings

INSPIRE could be very relevant for energy assessment in the built environment and for this reason the Energy Pilot initiated under the "Energy and Location" and "European

[10] http://e3p-beta.jrc.nl

Union Location Framework" projects will be continued over the next years. Main objectives of the pilot project will be to continue to work on Use Cases outlined in the introductory section of this report.

In particular, the INSPIRE harmonisation of existing energy performance certificate datasets (Use Case 1) will be continued and implemented in other countries; the benchmark of different methodologies for Energy Performance Labelling of buildings (Use Case 2) will be initiated, based on the best practices presented in this workshop; a methodology to assess the Energy Performance of buildings with dynamic measured data (Use Case 3) will be developed and tested; and further work supporting Energy Efficiency driven renovation planning of the building stock at local level (Use Case 4) will be planned and initiated. JRC will further elaborate the identified Use Cases based on the information gathered at the workshop and will seek to develop partnerships to jointly implement them.

In order to ensure dissemination of the results of these activities in both communities (INSPIRE and energy efficiency of buildings), a proposal will be made to the organizers of the INSPIRE conference next year (early September 2017) to devote time and effort to have the building energy society involved in, e.g. *Theme on Energy in Built Environment*. DG ENER and DG ENV could be contacted to elaborate this proposal, taking into account the relationships of the energy related Directives, such as the EPBD, the EED and the voluntary initiative of the Covenant of Mayors with the INSPIRE Directive. The DGs that could be involved are DIGIT (the ISA^2 programme), ENV (INSPIRE), ENER (Smart Cities), RTD, GROW and JRC (research on INSPIRE, location interoperability and support to energy policy).

Figure 2 Invited experts and JRC participants to the workshop.

APPENDIX I - Invitation letter sent to external experts

Foreword

This Workshop is jointly organised by the Directorate B – Growth and Innovation - Digital Economy Unit and the Directorate C – Energy, Transport and Climate - Energy Efficiency and Renewables Unit of the European Commission Joint Research Centre (JRC).

Directorate B – Growth & Innovation

The mission of the Directorate for Growth and Innovation is to conduct research that provides science-based, customer-driven socio-economic and techno-economic support for the conception, development, implementation and monitoring of EU policies.

Digital Economy Unit

The mission of the Digital Economy Unit is to provide quantitative and qualitative socioeconomic research in support to the Digital Economy, Digital Living and Digital Society; to analyse data value chains and the conditions relating to their development; to provide the technical coordination of the INSPIRE Directive developing the European Spatial Data Infrastructure (SDI) for sharing data, information and knowledge and leading to the development of the next-generation of SDI (Digital Earth).

Directorate C Energy, Transport & Climate

The Directorate is carrying out research in both nuclear and non-nuclear energy domains, with partners from the Member States and beyond. In state-of-the-art experimental facilities, it carries out key scientific activities in the following fields: renewable energies including solar, photovoltaics and biomass; sustainable and safe nuclear energy for current and future reactor systems; energy infrastructures and security of supply; sustainable transport, fuels and technologies including hydrogen and fuel cells as well as clean fossil fuel; energy techno/economic assessment; bioenergy including biofuels; energy efficiency in buildings, industry, transport and end-use.

Energy Efficiency and Renewables Unit

The JRC Energy Efficiency and Renewables Unit provides scientific and technical support to the Commission services (DG ENER, DG ENV) for the design, the implementation and the monitoring of the EU energy efficiency policies and programs. Moreover, a number of EU programs are managed directly by the JRC on behalf of DG ENER.

The Unit is linked to several international and national organisations (such as, CEN, ISO, IEC and IEA), research labs and universities operating in the field of energy efficiency. The JRC takes part in several experts network. Improving the efficiency with which energy is consumed by end-users and the energy performance of buildings is a central theme of energy policy within the European Community, since improved energy efficiency meets all three goals of energy policy, namely security of supply, competitiveness and protection of the environment.

Objectives of the workshop

During these days a number of presentations will highlight the challenges that are encountered when running projects or developing methods for a proper integration of energy systems in our society, in particular the built environment. Up to 40% of final energy consumption is in the residential and tertiary building sector and has an important energy reduction potential and hence a contribution to reduce the GHG emissions in Europe.

The recent technologies for gathering and elaborating data have to be employed and could contribute importantly to the goal of improving energy usage: "doing more with less" energy.

So far the JRC team has produced a feasibility study and started a dedicated pilot project on location data for buildings related energy efficiency policies[11]. The workshop is an opportunity to share information, integrate stakeholders' views and set the ground for mutual collaboration.

The first event organised was the workshop on "*Spatial data for modelling building stock energy needs*" held at JRC in Ispra 23-25 November 2015.

The aim of this second workshop is to discuss different approaches and methodologies to assess energy efficiency measures as well as energy usage and monitoring of energy flows at building, urban and regional level. The objective is also to share experience in developing methodologies that deal with big data about energy flows in the building area. The aim is to support energy efficiency policies and help scope a pilot to establish a harmonised approach supporting European Directives on Energy Efficiency, Energy Performance of Buildings, establishing a Infrastructure for Spatial Information in Europe (INSPIRE) and the Covenant of Mayors initiative using INSPIRE as a 'location' framework.

The workshop will include presentations and discussions on selected studies from cities, EU projects on the topic of the development of a methodology for monitoring of public and non-public buildings energy related consumption data (e.g. electricity, gas, water and other) in order to gain expertise on data-collection and quality for the assessment of energy usage in buildings, urban and regional areas.

The organisers hope for a fruitful workshop and invite all participants to actively take part in the discussions.

Hans Bloem
Albana Kona
Isabella Maschio
Silvia Rivas
Francesco Pignatelli
Maria Teresa Borzacchiello
Ray Boguslawski
Giacomo Martirano

[11] http://e3p-beta.jrc.nl/articles/pilot-project-energy-and-location

APPENDIX II - Workshop Agenda

"Methodologies for energy performance assessment based on location data"

JRC Ispra (IT), 12 – 14 September 2016

Terra Meeting Room – Bld 100

Monday, 12 September 2016

12:30 – 14:00	Welcome Lunch
14:00 – 15:00	– Welcome from host *Diana Rembges and Maria Teresa Borzacchiello (JRC)* – Short introduction by all invited participants – Background information: o The European Union Location Framework (EULF) o JRC feasibility study "Location Data for Buildings related Energy Efficiency Policies" o Outcomes of the first workshop "Spatial Data for Modelling Building Stock Energy Needs" o Objectives of the JRC pilot project o E3P Platform *Maria Teresa Borzacchiello, Giacomo Martirano, Hans Bloem, Isabella Maschio (JRC)* – Workshop introduction, objectives and modalities. *Maria Teresa Borzacchiello, Giacomo Martirano, Hans Bloem (JRC)*
15:00 – 15:30	– Building Energy Performance and Location – JRC Energy & Cities project; from building to urban area *Hans Bloem (JRC)*
15:30 – 16:00	Coffee break
16:00 – 17:45	– The methodological approaches in the EU project DIMMER *Vittorio Verda (Politecnico di Torino, IT)* – Methodologies for energy performance assessment based on location data: examples from EU projects *Piergiorgio Cipriano (Sinergis, IT)* – Towards an European Scale Platform for Urban Energy Simulation *Volker Coors (Center of Applied Research, Sustainable Energy Technologies - University of Applied Sciences Stuttgart, DE)*
18:00	Transfer to hotel

Tuesday, 13 September 2016

9:00 – 10:30	– Using location data to implement policies on energy performance of buildings: use cases from the Netherlands Kadaster *Martinus Vranken (The Netherlands' Cadastre, Land Registry and Mapping Agency, NL)* – Presentation of the IEA EBC Annex: "Building Energy Epidemiology: Analysis of Real Building Energy Use at Scale" *Paul Ruyssevelt (UCL Energy Institute - University College London, UK)*
10:30 – 11:00	Coffee break
11:00 – 12:30	– Energy and Location Methodology: CIMNE's point of view *Jordi Carbonell (CIMNE, ES)* – Space heating models for residential buildings and the influence of urban variables *Guglielmina Mutani (Department of Energy - Politecnico di Torino, IT)*
12:30 – 14:00	Lunch
14:00 – 15:30	– Energy simulation of buildings and urban projects. Spatial data input, use of measurements, «big data» *Bruno Peuportier (MINES ParisTech – Center for energy Efficiency of Systems, FR)* – Heat Roadmap Europe: Methodologies for Spatial Analysis in Demand and Resource Mapping *Urban Persson (Halmstad University, SE)*
15:30 – 16:00	Coffee break
16:00 – 17:45	– Methodologies for energy performance assessment based on location data *Nina Detlefsen (District Heat Association, DK)* – Identifying the Thermal Characteristics of Buildings using Data *Henrik Madsen (Applied Mathematics and Computer Science, Technical University of Denmark, DK)*
18:00	Transfer to hotel
20:00	Social dinner at the Hotel dei Tigli

Wednesday, 14 September 2016

9:00 – 10:30	– Conclusive reports of session rapporteurs – Identifying Use Cases and Methodology approaches – Discussion with all invited experts *All workshop participants*
10:30 – 11:00	Coffee break
11:00 – 12:30	– Explanation to collaboration agreements – Wrap-up and next steps – Conclusions of the experts to the workshop/meeting *All invited experts*
12:30	Workshop closure

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